periments are constantly going on, looking towards both the improvement in these dressings and also in the extension of the usefulness of sphagnum along other lines.

J. W. Hotson
The University of Washington,
Seattle, Wash.

A NEW SEASONAL PRECIPITATION FACTOR OF INTEREST TO GEOGRAPHERS AND AGRICULTURISTS

Most persons who have attempted to correlate soils and vegetation with atmospheric precipitation have directed their attention chiefly to the total annual rainfall and its variations from place to place.[1] It has long been recognized that seasonal distribution also needs to be taken into consideration, but there has been no unanimity as to how seasonal variations of rainfall should be treated. Some have simply mapped the total precipitation for each month or season separately, or indicated the months of maximum rainfall in different regions; but a more common method has been to map the percentage of the total occurring in the six middle months of the calendar year, April to September inclusive.[2] Such an arbitrary division is rather unscientific, however, for in the eastern United States, if not throughout the northern hemisphere, the warmer half of the year usually extends from the latter part of April to the latter part of October, so that May to October inclusive would more nearly represent it.[3] The use of the earlier period has been defended on the ground that April rain is more beneficial to crops than October rain, which is probably true (and so would March rain be better than September rain); but the type of rainfall that is best for crops, other things being equal, is not necessarily best for soil in the long run. A warm rain presumably has a greater leaching effect than cold rain or snow, and regions subject to heavy summer rains, like most of Florida, generally have poorer soils and more swamps than where the summers are dry, as in California.[4]

In recent years the writer has calculated the rainfall percentages for May to October and also for June to September for numerous stations in the southeastern states, and thereby shown some interesting correlations with soil and vegetation.[5] But when these factors are mapped for the whole United States the correlation does not work out so well. For the northern part of the Great Plains has about the same proportion of its total rain in summer as peninsular Florida, but very different soils and vegetation. Of course part of the difference is due to the fact that the total rainfall and average temperature are much less on the Plains than in Florida. But there is another important climatic difference.

In the Great Plains and much neighboring territory the bulk of the rain falls in early summer, while along the Atlantic and Gulf coasts there is generally more rain in late summer than in any other equal period. Consideration of this fact recently led to some comparisons between early and late summer rainfall for the whole United States. After some experimenting it was found that the most striking results were obtained by taking the difference between the rainfall for April to June inclusive and that for August to October inclusive,[6] the former being good for the

[1] For such correlations between soil and rainfall see Bulletin 3 of the U. S. Weather Bureau, by E. W. Hilgard, 1892. A review of this, which may be more accessible than the original, can be found in the *Experiment Station Record*, 4, 276–282, October, 1892.

[2] For a map of the United States on this principle see Plate 2 in U. S. Geological Survey Water Supply Paper 234, 1909.

[3] See *Geol. Surv. Ala. Monog.* 8, 24; *Bull. Torrey Bot. Club*, 40, 395, 1913.

[4] Dr. A. D. Hall, of Rothamsted, in an address on agricultural extension problems published in the *Popular Science Monthly* for October, 1914 (p. 349), says: "Winter rain is more valuable than summer."

[5] See *Bull. Torrey Bot. Club*, 37, 415–416; 40, 395; 41, 556–557; *Geol. Surv. Ala. Monog.* 8, 19 24, 36, 1913; *Fla. Geol. Surv. Ann. Rep.*, 6, 182–184, 1914; also Ward in *Bull. Am. Geog. Soc.*, 46, 47, January, 1914.

[6] If climatological data for fractions of months were available we could include the first half of July in the early summer period and the second

crops and the latter bad for the soil. Data for a few hundred stations were taken from Bulletin Q of the U. S. Weather Bureau, which although it brings the records down only to the end of 1903, and contains a few typographical errors in the figures, is easier to handle than any later publication covering the same ground, and is probably accurate enough to base a working hypothesis on.

The resulting map differs considerably from any other precipitation map, but instead of publishing it in its present imperfect state a brief description will be given. The line of equilibrium, where there is no difference between early and late summer rainfall, crosses the St. Lawrence River in northern New York and extends in a general southwesterly direction, with various sinuosities (perhaps due largely to differences in altitude and exposure between neighboring weather stations in the Appalachian region) to the vicinity of New Orleans, thence westward, passing between Houston and Galveston, to near Del Rio on the Rio Grande, northwestward across the Staked Plains to the Rocky Mountains in Colorado, westward to Monterey County, California, and then southeastward just back of the Coast Ranges into Mexico. Another part of it separates the northern half of Michigan, northeastern Minnesota, and part of Wisconsin from the states to the southward, then passes northwestward into Canada and dips back into the United States just enough to cut off the north end of Idaho and the northwest corner of Washington. The borders of the United States are mostly in the region of late summer excess, while approximately three fourths of the country, including almost the whole area drained by the Mississippi River, has an early summer excess. The greatest late summer excess, about 11 inches, is on the east coast of Florida,[7] and the mouths of the Mississippi and Rio Grande are not far behind. The Black Hills have an early summer excess of about 6 inches, and the area having more than 4 inches extends all the way from Montana to Alabama. If ratios instead of differences had been used the position of the zero line would have remained the same, but the gradient would have been steepened in the drier parts of the country.

half in late summer, and perhaps get still greater contrasts.

[7] Nassau in the Bahamas, about 180 miles farther east, has a late summer excess of nearly 13 inches.

The map here described suggests at once some very interesting correlations. Considering other climatic factors first, nearly all our tornadoes occur in the region of considerable early summer excess of precipitation, and our hurricanes in that of considerable late summer excess, while regions where the difference is not more than an inch or two either way rarely suffer much damage from wind. Both tornadoes and hurricanes usually occur during the period of greatest rainfall in their respective regions.[8]

The late summer rains commonly come in the form of showers in the daytime, while the

[8] There is a tornado frequency map of the United States by J. P. Finley in Professional Paper No. 7 of the U. S. Signal Service (1882), reproduced on a smaller scale with fewer details by R. DeC. Ward in *Quart. Jour. Roy. Meteorol. Soc.*, 43, 323, 1917. This is based on 600 tornadoes occurring between 1794 and 1881, but is a little misleading, because in the early part of that period the regions where tornadoes are most frequent were practically uninhabited by civilized man, and thus the apparent frequency of such phenomena in the older states is exaggerated. Of the 40 tornadoes prior to 1850 reported by Finley, 9 were in New York, 5 in Ohio, 3 in Connecticut, 3 in Georgia, and none in Kansas and Illinois, which now lead the list. A map based on records from about 1870 to date would be more accurate; but even Finley's map shows a fair degree of correspondence between tornadoes and early summer rainfall excess.

It appears from Bulletin X. [not 10] of the U. S. Weather Bureau, on Hurricanes in the West Indies, by Dr. O. L. Fassig (1913), that there are only three well-marked hurricane regions in the northern hemisphere, all lying between latitudes 5° and 30° N., and all having a maximum storm frequency in September. In the United States hurricanes are most frequent in Florida, but they are occasionally felt as far north as the coast of Massachusetts.

early summer rain is more likely to fall gently, and at night. In the southwestern semi-arid late summer rain area (*i. e.*, Arizona, New Mexico and adjacent territory) the railroads have been put to considerable expense to build dikes to protect their tracks from sheet-floods following summer showers, while in northern Nevada and Utah, where the total precipitation is about the same, but its seasonal distribution different, no such precautions seem to be necessary. Floods of the ordinary type, caused by overflowing rivers, are much more frequent and destructive in the region of early summer rains, however.

If there was such a thing as a soil fertility map of the United States it would be seen at once that the most fertile soils are in the region where there is more rain in early summer than in late summer, and vice versa. Considering texture only (for we now have much more complete data on that than on chemical composition), we can ascertain from published soil surveys that silt loam—which is usually considerably above the average in fertility—is one of the commonest types of soil throughout the Mississippi valley, whether it is derived from weathered Paleozoic rocks, as in Tennessee, from glacial drift, from glacial lake deposits, as in North Dakota, or is of æolian origin, as the loess of Arkansas and Mississippi is supposed to be. Clay loam and stony loam are other common types in the same area, nearly or quite as fertile as the silt loam, while sand is chiefly confined to the banks of streams. The black prairies of Alabama and Texas, characterized by very fertile calcareous clays, are both in the area of early summer excess of rain, although when semi-annual percentages only were considered, as heretofore, the line of equal summer and winter rains passed between them. One would naturally suppose the flood-plain of the Mississippi below the mouth of the Ohio to be one of the most fertile tracts in the world; and so it is where it has more rain in early summer than in late summer, and most of the farmers in that portion use no commercial fertilizer whatever. But in several parishes below New Orleans, where the late summer rain is in excess, the average expenditure for fertilizers in 1909 was over a dollar per acre of improved land! (For the whole United States at the same period the average was about 24 cents.)[9]

The regions of heavy late summer rain are characterized by poor sandy soils, classed by the U. S. Bureau of Soils as sand, sand-hill, sandy loam, fine sandy loam, etc., and silt loam and clay are comparatively scarce. The sandiest extreme is in peninsular Florida, but northern Michigan, Cape Cod, and southern Texas are also notoriously sandy. Swamps too are about as prevalent in northeastern Minnesota and northern Michigan as they are in Florida. Although the late summer rain area covers only about one fourth of the United States and produces considerably less than one fourth of the crops, it uses at least three fourths of the commercial fertilizer; the average annual expenditure for that in some of the southeastern counties of Florida at the time of the Thirteenth Census being about $30 per acre.[10] And even in California there is considerable fertilizer used in the southeastern portion.

In all these eastern sandy and swampy areas the streams carry very little sediment and do not fluctuate much. In the corresponding parts of the Southwest there is not so much sand, but the type of soil known as adobe (and used extensively for building material) is very characteristic.

The distribution of vegetation types is of course correlated with the soil to a considerable extent. Except in the Northwest the forests of the early summer rain area are composed almost wholly of deciduous trees, and there are vast areas of prairie; while conifers, especially pines, predominate in northern Wisconsin, Cape Cod, southern New Jersey, Florida, and many other places where there is more rain in late summer. The most extensive pine forests in North America are said by Professor Sargent[11] to be those of western

[9] In this connection see SCIENCE, II., 42, 500–503, October 8, 1915.

[10] See *Geog. Review*, 4, 225, September, 1917.

[11] "Manual of the Trees of North America" (1905), p. 16.

yellow pine in northern Arizona and New Mexico. Most of the cacti in the United States are restricted to the southwestern area of late summer rains, and the same might be said of the species of *Yucca* and related genera.[12] (Both groups consist entirely of evergreens, and both have also several representatives in the Southeast.) The gymnosperms other than conifers (*i. e.*, Taxaceæ, Cycadaceæ, Gnetaceæ), as well as the palms and Ericaceæ, show a somewhat similar preference for late summer rain, in the United states at least.

The same precipitation factor seems to control indirectly several economic features. For example, most of the developed water-powers in the United States are within two or three hundred miles of the line of equilibrium between early and late summer rains, though this may be chiefly because the same topographic factors that make the water-power possible also influence the seasonal rainfall in some way. Some correlations between seasonal rainfall and crops are easily made. Alfalfa, wheat, figs and upland cotton are not raised much where the late summer rainfall exceeds that of early summer by more than three inches, while sugar-cane, pineapples, grape-fruit and sea-island cotton thrive where late summer rains prevail. But of course the soil has a great deal to do with this too.

It would be interesting, and comparatively easy, to determine how far the same seasonal precipitation factor can be correlated with soils, vegetation, etc., in other parts of the world. The explanation will not be quite so easy, for cause and effect are involved in a complex manner. Some of the marked soil differences between the Mississippi valley and the Atlantic coastal plain can be explained very well on geological grounds, wholly independently of modern climatic factors; and it may be that the deciduous forests and prairies that characterize the richest soils are conducive to early summer rains, and *vice versa*, in some way not yet understood.

The factor here discussed probably does not have exactly the same significance in cold as in warm climates, in humid as in dry, or in regions of wet winters and dry summers, like the Pacific coast, as in regions with wet summers, like Florida. All this deserves further investigation; and it may be found that by shifting a little the periods compared more significant results can be obtained.[13]

Roland M. Harper

College Point, N. Y.

[12] See Plate 99 in the 13th Annual Report of the Missouri Botanical Garden, 1902.

[13] The interested reader would do well to consult Professor R. DeC. Ward's paper on rainfall types of the United States, in the *Geographical Review* for August, 1917, and some of the earlier literature referred to therein and in the two pages following it.

PLANS FOR THE PHYSICAL RECONSTRUCTION OF DISABLED SOLDIERS[1]

The Surgeon-General, with the approval of the General Staff, announces the completion of plans for the physical reconstruction of disabled soldiers in the general military hospitals. These plans are formulated with a view to close cooperation with the War Department committee on education and special service in the work of restoring men to full or limited military service, and with the Federal Board for Vocational Education, which is authorized by the law to provide vocational training for disabled men after their discharge from the army and navy.

The records of 516 cases treated in four hospitals shows 134 men able to return to full military duty, 210 fit for limited service, and 172 who are eligible for discharge. In the last group 12 are classed as helpless or institutional cases; 121 are able to return to their former occupations; and 39 will need further training to fit them for earning a livelihood. These figures show the division of responsibility in the work of reconstruction.

The task of fitting men for further military service is at present the most pressing need because wherever an able-bodied man behind the lines can be replaced by one less fit physically, but vocationally capable, a soldier is gained for active duty. The reconstruction work in the hospitals, therefore, will emphasize tech-

[1] Publication authorized by the War Department.